September 12, 2007

Dr. Les Harder
Deputy Director for Public Safety and Business Operation
California Department of Water Resources
1416 Ninth Street, Room 115-19
Sacramento, CA 95814

Subject: Response to Independent Review Panel (IRP) Review of Delta Risk Management Strategy (DRMS) Phase 1 Risk Analysis Report

Dear Dr. Harder:

The purpose of this letter is to acknowledge and provide an initial response to the IRP review comments of the DRMS Phase 1 Risk Analysis Report. We appreciate the effort of the IRP members that is represented by these comments and believe the comments will be helpful in achieving an improved product.

We also appreciate the distinction the IRP members made between Tier 1 and Tier 2 comments. In this letter, we primarily provide preliminary responses to the Tier 1 comments. As our response effort progresses, we will fully address both the Tier 1 and the Tier 2 comments and revise the Phase 1 reports accordingly (Summary Report, Risk Analysis Report, Ecosystem TM, and other TMs, as necessary).

We believe the IRP comments can be categorized into three broad categories:

- Improved transparency and documentation
- Editorial and organizational improvements
- Technical questions, comments, and suggestions

With respect to the first two items, we agree that the report can be significantly improved with additional time and effort devoted to address these areas of concern. These two categories encompass the majority of the IRP's Tier 1 comments.

Regarding the technical issues that were raised, we value the opportunity to address the areas of concern and, where necessary, improve the analysis and reports. However, in some specific areas, we believe that the views expressed by the IRP members are incorrect. In the following bullets, we highlight the technical aspect of each Tier 1 comment and summarize the direction we intend to take in our response:

1. ***Lack of Transparency of Analyses.*** This comment is primarily a documentation/editorial issue and will be addressed in the next revision of the report. The discussion of the development of the analyses (assumptions, methods, results,

and interpretation of results and how they fit with the overall risk model) will be expanded. The Phase 1 Risk Analysis Report (and if needed, the TMs) will be reviewed and the text expanded to provide a complete description of the methods used and the evaluations performed. We will also provide a clear and consistent definition of the terminology we use in the reports.

A comment is made with regard to comparisons (spot-checking) of previous studies. We are not clear from the comment which other previous studies the reviewers are referring to. Nonetheless, we will add a discussion that compares the DRMS risk analysis to other studies and highlight the reasons for any differences between our results and the results of the other studies. Examples of the previous studies that we will reference include the CALFED 2000 levee seismic vulnerability study, the 1992 Department of Water Resources Seismic Stability Evaluation of the Sacramento-San Joaquin Delta Levees (this report contains a complete summary of relevant previous studies), the Jack R. Benjamin & Associates (JBA) 2004 risk analysis, the USGS national hazard maps, and other applicable references to other topics presented in the report.

The revised report will include complete and adequate responses to all of the comments.

2. ***Limited Actual Analyses Carried Through to the End.*** Again, we believe that with proper documentation of how the analyses are carried out in the Risk Analysis Report, we will be able to address the reviewer concerns. However, it would be helpful to get a more specific description from the reviewers as to what is meant by, "*The probabilities and consequences are not integrated over the full range of possibilities...*"

   As far as the specific areas raised by the IRP, we have provided some preliminary answers below. First, as a general response to this comment, we will add the necessary documentation of the analyses for the various topics, the treatment of uncertainty, and the limitations and the assumptions applied. We will also provide the justifications for the limitations and assumptions and their practical reasons. In places where we applied simplifications, we will fully explain and justify them (see some preliminary responses in item 3 below). In other places, we will conduct additional analyses as requested by the reviewers. For example, we will show the high-frequency, low-consequence hydrologic events. However, these events will not change the frequency of failures for the other analysis cases (moderate- to low-frequency flood events). The disruption of water supplies due to flood-induced single-island failure was found to be insignificant and are not expected to lead to significant degradation of water quality and hence to interruptions of water export. Furthermore, we will also add probable life loss to our estimate of the population at risk.

   As for the estimated probability of levee failure due to a seismic event, we maintain our conclusions on the expected future probabilities of earthquake occurrences, the results of the probabilistic seismic hazard analysis (PSHA), and their impacts on the levees. We note that the PSHA is based on the USGS seismic source models for the

major Bay Area faults, and the analysis was reviewed by both the USGS and the California Geologic Survey (CGS). Because many updates have been made to the seismic hazard models in recent years, we believe that the previous studies are no longer applicable. Specifically, the 2002 National Hazard Map ground motions, HAZUS model, and CALFED 2000 study (work done in 1999) do not include the recent updates of the seismic sources, the new attenuation relationships, the time dependency, or more recent site-specific data. We discuss these key points further below.

a) The National Hazard Maps do not include a time-dependent element in their development. The unique aspect of the DRMS PSHA was the inclusion of the time-dependent behavior of the seven major Bay Area faults (e.g., the San Andreas fault) as characterized by the Working Group on California Earthquake Probabilities.

b) The 2002 National Hazard Maps use ground motion attenuation models that date back to 1997. The DRMS PSHA utilizes the recently released (2007) Pacific Earthquake Engineering Research (PEER) Next Generation Attenuation relationships, which represent the state of the art.

c) We have used the recent, site-specific material properties that Professor Ross Boulanger of UC Davis developed for organic soils in the Delta in 2006 and 2007.

d) The CALFED 2000 analysis divided the islands into four zones, whereas our analysis is carried out island by island and reach by reach for each island.

e) A purpose of the DRMS PSHA is to ensure that the epistemic uncertainty (uncertainty that cannot be further defined with additional sampling and testing) in the seismic source characterization is properly incorporated. The philosophy of the National Hazard Maps is to estimate mean hazard and in so doing, they do not include the epistemic uncertainty in all seismic source parameters. The maps only include seismic sources, which have been described in published sources. Thus, recent research on seismic sources that has yet to be published is not included in the maps.

f) Of particular significance to the DRMS study are the in-Delta faults, which have been characterized as part of the PSHA. These seismic sources, including the Midland fault (which is described in a publication), are not included in the National Hazard Maps.

g) The National Hazard Maps are for a firm rock site condition (average shear wave velocity in the top 30 m of 760 m/sec). The DRMS PSHA was performed for a Delta-specific site condition where the shear-wave velocity in the stiff clay substratum (reference site) is 335 m/sec. In the analyses, these motions were

then propagated up through the soft, Delta deposits to estimate the actual site-specific ground motions that would occur at the levee sites.

3 ***Limited Treatment of Uncertainty.*** We acknowledge that the treatment of uncertainties is not highlighted in the documentation equally among the various topics covered. We will expand and make uniform the coverage of uncertainty in the Risk Analysis Report. As discussed at our meeting with the IRP in March, in some areas of the study uncertainties could not be evaluated due to the level of work that would be required to make a credible assessment. In the areas where the uncertainty evaluation could not be carried out (i.e., economics, hydrodynamic and water management, ecosystem impacts, and climate change), we will provide ranges and clearly state justifications for these simplifications. On this point, we note that during the meeting with the IRP, one of the panel members indicated that in his view the epistemic uncertainties in an ecosystem analysis are so great that assessing them and displaying them are counterproductive to decision making.

In conclusion, we plan to add a more substantive discussion of the treatment of uncertainty where it has been evaluated and propagated in the analysis, and where it has not been addressed, we will explain why.

4 ***Lack of Integration of Analyses.*** As reflected by the specific wording of the IRP comment, this is less about a "lack of integration of analyses" and more about completing and documenting the analyses and providing QA/QC for the integration. Our action plan is to provide a more detailed description of the integration of the various parts of the risk model and more documentation on the QA/QC process followed.

5 ***Lack of Robust Methodology for Assessing Impacts on Aquatic Resources.*** We agree that the methodology for assessing quantitative aquatic impacts can be improved. However, we would also like to state that general approval and consensus among the practicing community does not currently exist on any model or its parameters given present limitations on scientific understanding. We are planning to meet with our technical advisors (as recommended by the IRP) and plan to extend and improve the eco-risk model and to consider a direct assessment of the probability of impacts and/or extinction.

Sincerely

URS Corporation
Said Salah-Mars, Ph.D., P.E.
Vice President
URS Corporation
DRMS Project Manager

Jack R. Benjamin & Associates
Martin W. McCann Jr., Ph.D.
President
Jack R. Benjamin & Associates
DRMS Technical Manager